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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1711

# WHEAT SMUTS AND THEIR CONTROL

CLOUD OF SMUT SPORES FROM THRESHER

WHEAT is subject to a number of smut diseases. The purpose of this bulletin is to describe these diseases briefly, so that they may be identified by the grower, and to give recommendations for preventing them in subsequent crops.

All of the wheat smuts are seed-borne diseases. Three of them—flag smut and the two stinking smuts—also infest the soil under certain conditions. Insofar as the wheat smuts are seed borne, they may be controlled by seed treatment. The spores of the stinking smuts and of flag smut carried on the surface of the seed can be killed by chemicals, such as formaldehyde solution or copper-carbonate dust.

Loose smut, which is carried inside the seed grain, may be controlled by a hot-water treatment which raises the temperature of the wheat high enough to kill the smut but not high enough to seriously injure the seed.

This bulletin is a revision of and supersedes Farmers' Bulletin 1540, Smuts of Wheat and Rye and Their Control.

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# WHEAT SMUTS AND THEIR CONTROL

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## LOSSES FROM WHEAT SMUTS IN THE UNITED STATES

WHEAT in the United States is attacked by four smuts—two kinds of stinking smuts or bunts and loose smut and flag smut. The stinking smuts and loose smut are widely distributed in all wheat-growing areas in the United States, whereas flag smut is known to occur only in a limited territory.

Losses from wheat smuts are of two kinds — field losses, which result from reductions in yields, and discounts on the market, because of the foul odor and discoloration of wheat affected with stinking smut.

Estimates made by the United States Department of Agriculture in cooperation with officials of various States show that smuts of wheat cause an estimated average annual reduction of 25,714,000 bushels in the wheat crop of the United States. The estimated annual field losses from these smuts from 1920 to 1930, inclusive, are given in figure 1.

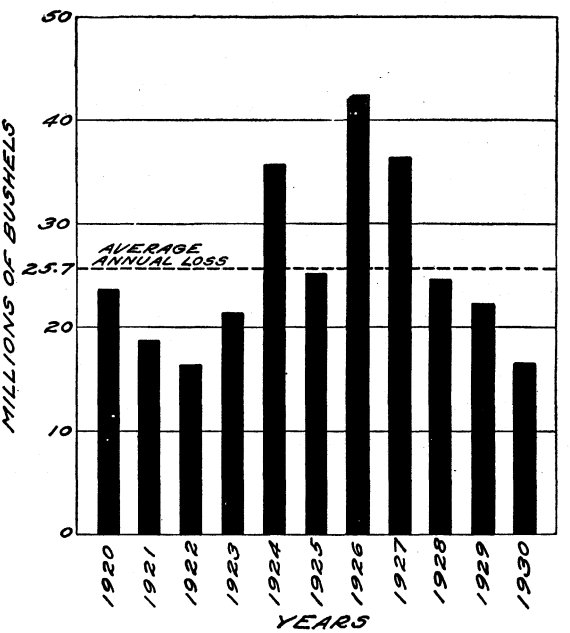


FIGURE 1.—Estimated annual field losses from wheat smuts in the United States, 1920–30.

In the case of the stinking smuts or bunts, which are responsible for about two thirds of the field losses from wheat smuts, the field damage is only a part of the loss. When the stinking smuts are present in wheat to any considerable extent, the foul, fishy odor given off by them permeates the entire mass of threshed grain, rendering it less desirable for flour making. The smut spores also blacken the grain more or less. The smut spores and the odor can be removed only by special cleaning and washing, the cost of which is reflected back to the growers through discounts or, in some sections, by a generally lower price for all wheat in the area. Discounts may run from 3 to 10 cents or even more a bushel. To losses in yield, therefore, must be added the market discounts on account of stinking smut or bunt, which may vary from $45 to $180 a carload, depending upon the amount of smut. The combined field and market losses in the United States, even at moderate wheat prices, amount to well over $15,000,000 annually.

The losses to the wheat farmer from stinking smuts or bunts may be better appreciated if reference is made to the results of a survey made in one county in Nebraska, where detailed records were kept from 1926 to 1930. In this county alone, losses from the stinking smuts averaged $237,590 annually. In 1930 the losses on 1,000 farms in that county averaged $276.87 per farm, or considerably more than the average annual taxes on the 1,117 farms in the same county. If such surveys were made in other wheat-growing areas, it is likely that similar losses would be found.

## STINKING SMUTS OR BUNTS

### DESCRIPTION

Stinking smuts or bunts are caused by two species of fungi, *Tilletia tritici* and *T. levis*, which are so similar in their characteristics and action upon the wheat plant that they will be discussed together.

The leaves of infected plants show a darker green color than normal at heading time, and, before ripening, the smutted heads also show a slightly darker green color than do the healthy heads. When such smutted heads are examined closely they are found to contain bunt balls instead of grain, and the anthers usually are less conspicuous than those in the healthy heads (fig. 2). The bunt balls are generally shaped like the kernels, but often are shorter and thicker, especially when the wheat is ripe, thus causing the glumes over the grain to spread apart more than is usual in healthy heads (figs. 2 and 3). Smutted plants also are often stunted.

When broken open, these smut balls are found to contain a mass of sooty black powder (fig. 4), the individual particles of which are the reproductive bodies or spores of the fungus. Many of these bunt balls are broken when the wheat is threshed, and the black powder is distributed over the healthy seed. If such contaminated grain is sown without first being treated, particularly if the weather is rather cool, the smut spores germinate at the same time the wheat does, and the parasitic threads of the fungus enter the young wheat


FIGURE 2.—A, A sound head of bearded wheat; B, a bunted head.

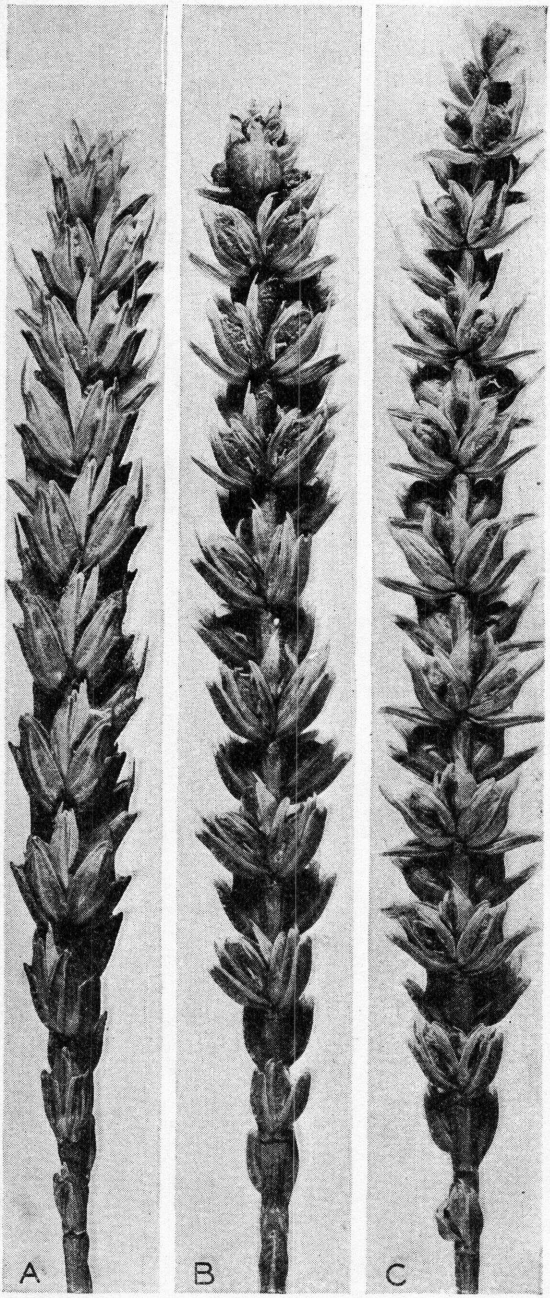


FIGURE 3.—Harvest Queen wheat: A, Sound head; B and C, bunted heads.

seedlings before they emerge from the soil. Once the fungus gets inside the young wheat seedling, it keeps pace with the growth of the wheat plant, and at heading time it forms masses of foul-smelling spores in the heads where normal wheat kernels should be.

## CONDITIONS INFLUENCING DEVELOPMENT

Experiments have shown that the stinking-smut fungi can infect the wheat plants much more readily when the soil is fairly cool, that is, when the soil temperature ranges from 45° to 55° F. Sowing wheat in a warm soil would be an effective method of reducing the percentage of these smuts, but the warm soil is unfavorable for the best development of the wheat seedling and also encourages the development of certain other diseases. Early sowing of winter wheat also is favorable for Hessian-fly infestation in many localities. Therefore, in most sections it is not advisable to sow wheat in warm soil.

The free smut spores on the seed may be easily killed by a number of chemicals. Therefore, if the seed grain is properly treated with any one of these effective chemicals before it is sown, the spores on the surface of the kernels will be killed without killing the wheat seed.

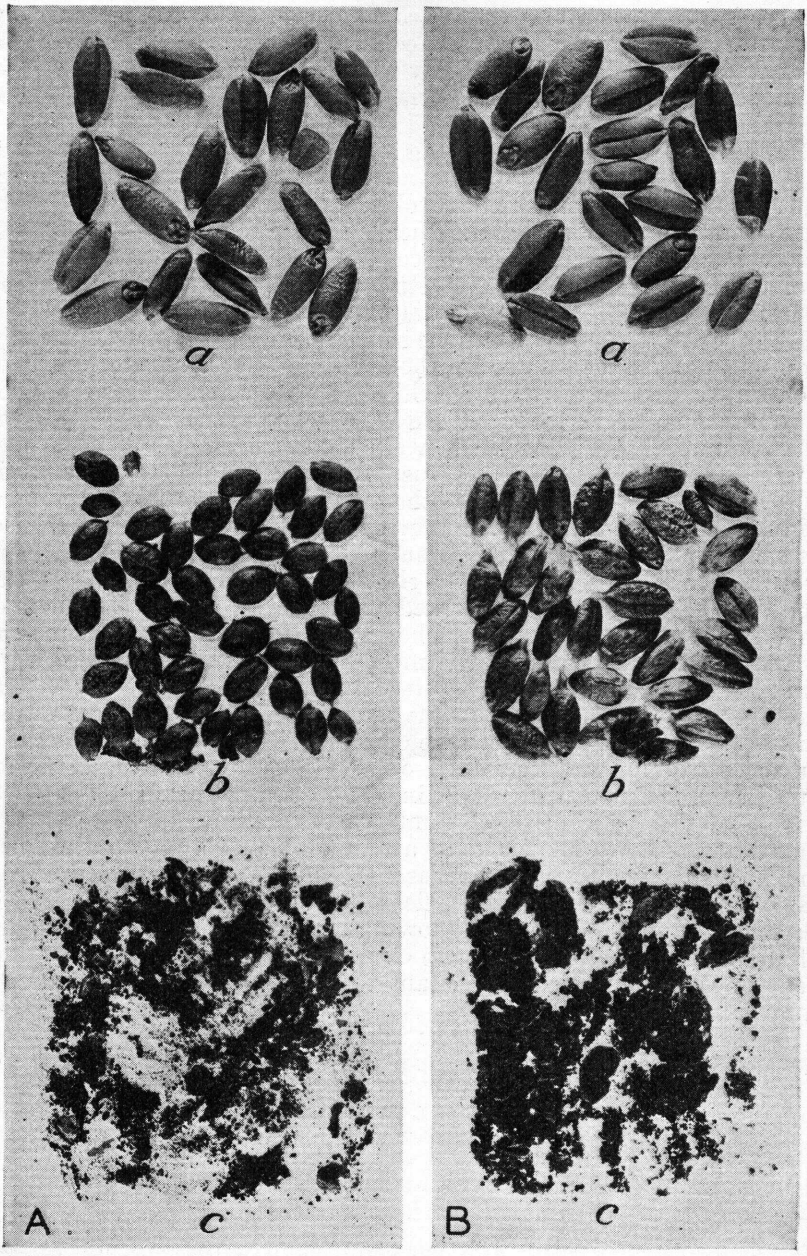


FIGURE 4.—A, *Tilletia tritici* on Kanred wheat: *a*, Wheat grains; *b*, bunt balls; *c*, smut spores. B, *Tilletia levis* on Harvest Queen wheat: *a*, Wheat grains; *b*, bunt balls; *c*, smut spores.

Sometimes the bunt balls are not broken during threshing, because the tough outer layer is a protection. The chemical usually does not penetrate through this layer to the smut spores inside. When these bunt balls are later broken, as they often are in handling

the grain or in the drill during sowing, they release live spores of the smut fungus, which may infect the young wheat plants. The unbroken bunt balls and partially smutted grains that are found in nearly all smutty wheat are especially troublesome in smutty durum wheat.

Soil infestation by the stinking smuts presents another difficulty in control. During harvesting and threshing of smutty wheat the bunt balls become more or less broken, and the spores may be blown over the ground where winter wheat is to be sown in the fall, as is shown in the illustration on the cover page. In some localities, especially in the Pacific Northwest and the Intermountain States, where summer-fallowing is almost universal, after the dry harvest season these spores may infest the soil to such an extent that the new crop will become infected, even though smut spores on the seed have been killed by seed treatment. This soil infestation is most common in those wheat areas characterized by a very dry harvest season and where summer-fallowing is practiced. Much of the wheat area where soil infestation is a serious problem is in isolated mountain valleys. It seems possible that the smut in these valleys is of local origin. If this is the case, a concerted use by all farmers of varieties resistant to the local races of smut, together with a seed-treatment program, may lead to practical elimination of the stinking smuts. The date of seeding has a marked influence on the development of smut in the subsequent crop, in that wheat sown in a warm soil may escape infection. A cool soil is most favorable for infection by the stinking smuts, and relatively little infection takes place at 70° F. However, it is not always possible to seed before the soil is cool, because of insufficient soil moisture or other reasons. Smut control is but one factor in the production of a wheat crop, and other factors must be given due consideration in a smut-control program.

No satisfactory control of bunt where soil infestation occurs is known at present. Experiments are now under way to obtain a better knowledge of (1) the local seasonal influences upon infection, (2) the relation of heavily infected fields to the development of smut in the surrounding fields in the following crop, (3) the number and distribution of the pathogenic races of the smuts, and (4) the development of suitable varieties resistant to as many of the races of the smuts as possible.

Fortunately, soil infestation is not likely to be a serious problem in the eastern winter-wheat and spring-wheat areas.

## CONTROL METHODS

The most important methods of controlling stinking smuts are (1) the use of clean seed or well-treated seed free of bunt balls and (2) the growing of resistant varieties.

### CLEANING AND TREATING SEED WHEAT

Several satisfactory seed treatments have been developed for the control of the stinking smuts. The first important step is to use seed wheat that is as free from smut as possible. Very smutty wheat should not be used for seed because of the difficulty of removing the bunt balls with present methods.

The second step is cleaning the wheat and removing as many bunt balls as possible. The seed wheat should be put through a fanning mill once or twice, as required. If the smut balls are not removed by this cleaning process, the most satisfactory treatment probably will be to use formaldehyde solution in open containers and skim off the floating bunt balls. Those that do not float probably will become sufficiently soaked with the solution to kill the spores.

Two methods of seed treatment are generally employed for the control of the stinking smuts: (1) Dust treatments, in which copper-carbonate dusts[1] and organic-mercury dusts are used; and (2) liquid treatments, in which formaldehyde solution and blue-vitriol solution are used.

### Copper-Carbonate and Organic Mercury Dust Treatment

The copper-carbonate treatment has become the most popular of the dust treatments for the following reasons: (1) It does not injure the grain, (2) the seed can be treated somewhat in advance of sowing and stored without injury, (3) dusted seed can be sown at any time in either dry or moist soil, (4) labor and expense of treating wheat for large acreages is reduced, and (5) treated grain is protected from weevils.

Only copper carbonate manufactured for treating seed should be used. This is available in two types. One type contains 52 to 55 percent of metallic copper and is known as pure copper carbonate, and the other type contains 18 to 26 percent of copper carbonate and is known as the diluted form. These dusts should be applied at the rate of 2 to 3 ounces to a bushel of seed. An excessive quantity of the dust will not injure the seed but may tend to clog the drill in humid weather. To be effective the dust must completely cover the seed.

Some of the organic-mercury compounds also satisfactorily control bunt. The dust to be used will depend largely upon the cost. The best way to obtain a thin film of the chemical dust over the entire seed is to mix the grain and dust in a rotary machine made especially for the purpose. Commercial treating machines are on the market, but satisfactory oil drum or barrel mixers may be made on the farm (figs. 5 and 6).

### Oil-Drum Mixer

A 30-gallon oil drum is a convenient size (fig. 5). Cut out half of one head. Bolt to the top of the remaining half a board 1 inch thick, 6 inches wide, and the proper length to fit snugly against the inside rim of the oil drum. Let 1 inch of the cut edge of steel extend beyond the board. Cut a semicircular wooden head to fit the open half of the drumhead and hinge this to the 6-inch strip. If necessary, nail a strip of an old inner automobile tube along the edge of the door to make it dust tight. Attach a hasp to hold the door tightly against the edge of the drum when closed.

The axle is made from ¾-inch pipe, 48 inches long, threaded at one end. It should pass diagonally through the drum, as shown in figure 5, and extend about 8 inches beyond each end. It is best to have the drum and axle welded together, but the axle may be bolted to the drum.

[1] See U.S. Dept. Agr. Misc. Circ. 108, Copper-Carbonate Seed Treatment for Stinking Smut of Wheat.

Nail or screw a mixing board, 1 inch thick by 6 inches wide, across the full inside width of the drum. Place the board edgewise and about two thirds of the way back from the opening, as illustrated (three nails being shown in each end of the board). Mount mixer on sawhorses.

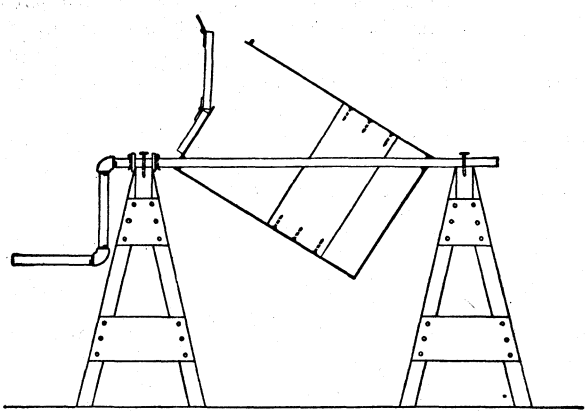

FIGURE 5.—An oil-drum mixer for treating seed wheat with copper-carbonate dusts. (Designed by R. S. Kirby, Pennsylvania State College.)

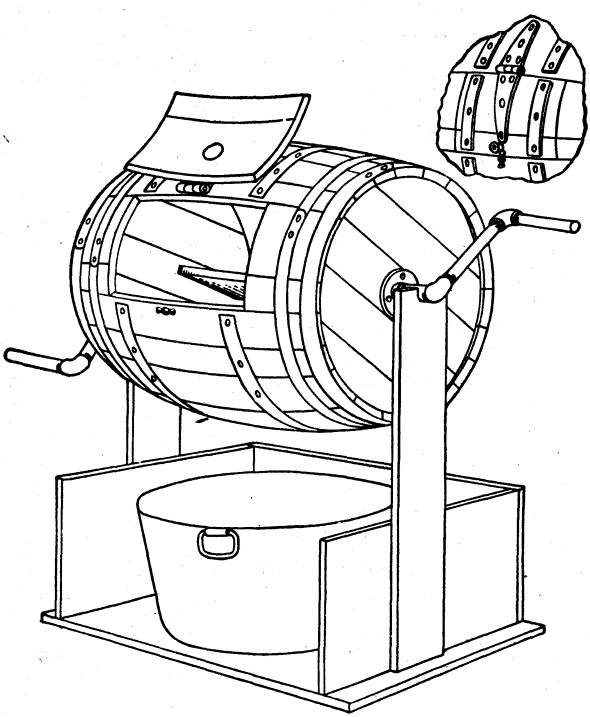

FIGURE 6.—A barrel mixer for treating seed wheat with copper-carbonate dusts. (Designed by F. W. Oldenberg, University of Maryland.)

### BARREL MIXER

Use a tight 30- or 40-gallon barrel made to hold liquids. Mark out a door about 8 inches wide by 14 inches long across two wide staves (fig. 6). Fasten hinge and straps to staves before sawing out the door. Saw the staves on

a slope toward the middle of the barrel to get bevel edges on the door. Line bevel edges with rubber from an old inner tube to make the door dust tight.

Insert a mixing board 1 inch thick and 9 inches wide along the full inside length of the barrel. Nail it to the ends of the barrel so that it lies edgewise against the inside of the barrel wall opposite the door, as illustrated.

On each end of the barrel screw or bolt a floor or railing flange threaded to hold 1-inch pipe. Insert a piece of 1-inch pipe 6 inches long in each flange to serve as an axle. Use 1- or ½-inch pipe for handles.

Mount the barrel on a boxlike stand, as shown in figure 6, or on sawhorses.

**CAUTION**

**Copper is poisonous.**

**Wear a mask or a wet cloth or wet handkerchief over the nose and mouth when treating grain with copper-carbonate dust. The treating should be done in a well-ventilated place.**

**Copper carbonate sifts into all working parts of the drill. After the drill has stood overnight or longer, turn the feed shafts with a wrench to free the feed wheels. This avoids possible twisting of feed shafts and breaking of gears. Oil the gear bearings frequently.**

**Do not use or sell treated wheat for food or feeding purposes.**

**Do not mix copper carbonate and wheat in the drill box or by shoveling over on the floor. Satisfactory control of smut is not obtained by these methods.**

### Formaldehyde Seed Treatment

The most commonly used liquid for controlling bunt is a formaldehyde solution made by thoroughly mixing 1 pint of commercial formaldehyde with 40 gallons of water. This should be sufficient for treating about 50 bushels of wheat. If the wheat is free from smut balls, coarse sacks may be half filled with the grain and immersed in the solution for 10 minutes. Care should be taken that every kernel of wheat is wet with the solution. At the end of 10 minutes the grain should be removed from the solution and allowed to drain. Enough seed may be treated the evening before to supply the grain drill the following day.

When the smut balls cannot be completely removed from the seed the treatment should be applied in open tubs, as shown in figure 7, in order to float off the bunt balls.

For treating large quantities of seed one of the commercial seed treaters may be used. These are built to float out the smut balls and wet the seed in a continuous process. For treating small quantities an open tub may be used. The seed can be poured slowly into the solution and stirred at the same time. Most of the smut balls will then come to the surface and should be skimmed off. After about 10 minutes the solution should be drained off through a screened hole at the bottom of the tub. If two such tubs are available the solution may be caught in the second tub and another lot of seed can be soaking while the first lot is being drained and sacked. All sacks should be free from smut to avoid recontamination of the seed.

Several precautions should be taken when formaldehyde solution is used: The solution should be of proper strength; the seed should be sown within 24 hours after being treated; the seed bed should be moist and the rate of seeding increased to compensate for the swollen kernels.

### RESISTANT VARIETIES

The breeding of varieties of wheat resistant to the stinking smuts is very promising, but it has been greatly complicated by the discovery of different races of bunt fungi. Some of the varieties considered resistant were found to be resistant to certain races only and susceptible to others. Thus, some varieties bred for bunt resistance were found to develop smut when introduced into localities where other races of smut fungi were present. In such cases, unless seed treatment is practiced, the percentage of smut is usually low at first, but increases each year as the amount of the new race of smut increases in the seed.

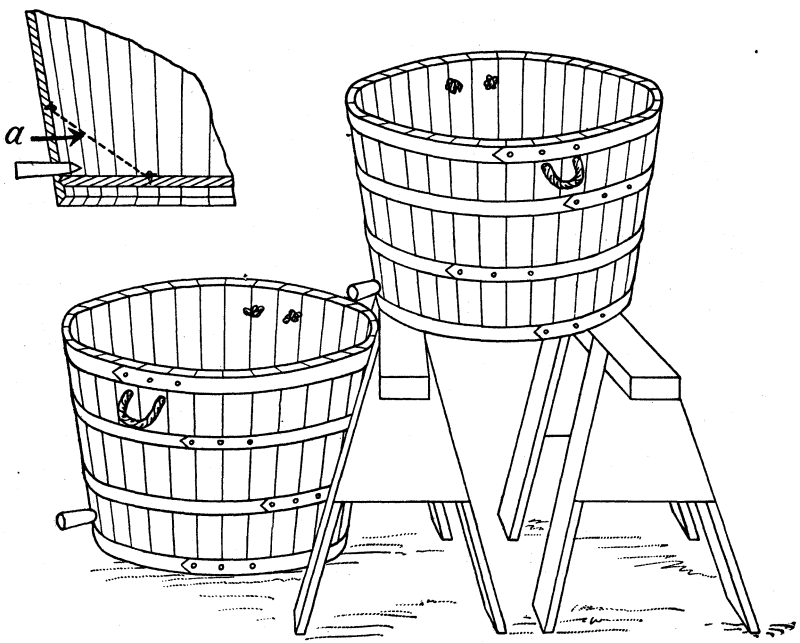


FIGURE 7.—Simple apparatus for applying the formaldehyde soak method of treatment to small quantities of seed. The screen (*a*) is for holding seed while draining off the solution.

Varieties of wheat are being developed which, it is hoped, will prove resistant to most of the important smut races in the localities where they are to be grown. These new wheats may be most useful in the areas where they are being developed, as they are selected for resistance to the races of smut prevalent in that particular area. They may not prove highly resistant in distant localities where they may be subjected to new and different races of the smuts.

It is very important, therefore, to treat the seed of supposedly resistant varieties, in order to prevent the increase of some virulent race or races of the smut fungi which in the beginning may be present in very small quantities.

If resistance were the only factor to be considered in a new variety, the task would be much easier. However, any new variety resistant

to smut must also have the other characters desirable for a good wheat in the locality where it is to be grown. It must be a good yielder, produce desirable milling grain, mature at the proper time, be resistant to other diseases, etc.

## LOOSE SMUT

### DESCRIPTION

Loose smut of wheat, commonly known simply as "smut" or "blackhead", is different from the stinking smuts and flag smut, the other smuts of wheat. As soon as the wheat heads out the smut is very noticeable (fig. 8). The diseased heads are almost completely destroyed by the smut. Instead of normal wheat, chaff, and flowers, black masses of smut, composed of spores of the smut fungus, *Ustilago tritici*, appear along the axis of the head. The spores are easily shaken from the smutted heads (fig. 9) and may be carried for long distances by wind, insects, or other agencies. The greatest distribution of loose-smut spores takes place at about the time the healthy wheat is in bloom (fig. 8). Some of the spores may lodge in the flowers during the short period in which the glumes open in blooming. Here the spores germinate and develop infection threads that grow into the very young wheat kernel inside the chaff. When mature, infected kernels cannot be distinguished from smut-free kernels. However, if such wheat is used for seed without first being treated, the smut fungus inside the seed starts to grow as the kernel germinates, spreading upward into the tender tissues of the plant as it develops. Finally, when the wheat heads appear they are composed of masses of smut. Wheat is infected by the loose-smut fungus only through the flowers. The disease does not infect wheat through the seedlings, as in the case of the stinking and flag smuts.

FIGURE 8.—Appearance of loose smut in wheat when the sound heads are in bloom.

## CONTROL METHODS

Because the loose-smut fungus is carried inside the seed, it is necessary to apply a treatment that will penetrate the seed and kill the fungus. Surface disinfectants that control stinking smut and other surface-borne smuts will not control loose smut. The hot-water treatment is recommended. If the treatment is properly applied, the heat penetrates the seed and kills the dormant fungus without killing the wheat germ, because the wheat can withstand higher temperatures than can the smut fungus.

FIGURE 9.—Wheat heads infected with loose smut as they look after the smut spores have been shaken off and the sound heads have begun to fill.

There are two other possible methods of controlling loose smut: To grow resistant varieties of wheat; and, in arid climates where wheat is grown under irrigation, to withhold water during the blooming period.

### HOT-WATER TREATMENT

Two different hot-water treatments have been devised, the modified hot-water treatment and the single-bath hot-water treatment. In the former the seed is presoaked for 4 hours in cold water, dipped in water at about 120° F. to warm the seed, and then soaked for 10 minutes in water at 129°. In the single-bath method the long presoaking in cold water is omitted and the seed is soaked for 1 hour and 50 minutes in water at 118.5° or for 1 hour and 35 minutes at 120°. In the 10-minute bath of the modified treatment, and throughout the single-bath treatment, care should be taken to maintain closely the recommended temperatures.

In both the modified and single-bath treatments soaking causes the seed to swell considerably. The sacks used in treating the seed,

therefore, should be only half filled and should be tied at the top. Only coarse sacks should be used. During the presoak period of the modified treatment and throughout the single-bath treatment the sacks should lie on their sides and should be turned or rolled occasionally to prevent caking of the swelling seed. Immediately after treatment the seed should be raked out in a thin layer to cool and dry. It is safer to sow the seed after it has been thoroughly dried, but it will run freely through the drill as soon as it is surface dry, when it may be sown. In the latter case the drill should be set at a higher seeding rate to allow for the swollen condition of the grain. Seed that is only surface dry still contains enough moisture to cause germination in a dry soil. If sown in dry soil, some of the seedlings may die and the stand may be severely injured.

The hot-water treatments are not recommended for treating seed for the entire crop, because they are difficult to apply and often cause injury to the seed, particularly when the seed coats have been broken in threshing or otherwise. If seed from smut-free fields cannot be obtained, it is best to treat only a sufficient quantity for sowing a seed plot, and the farther this plot is isolated from fields of untreated wheat the better the results will be. The crop grown on the isolated seed plot from treated seed and successive crops from the same seed lot may remain relatively free from smut, so that further seed treatment will not be necessary for a considerable period. However, reinfection of the seed in the seed plot may take place rapidly. The amount of smut in nearby fields and the influence of climatic factors on its spread and on its development in the wheat flower doubtless play an important part in this reinfection. If the seed wheat to be treated for loose smut also carries spores of the stinking smuts or bunts, the hot-water treatment will control both; but neither the copper-carbonate treatment nor the formaldehyde treatment recommended for the control of the stinking smuts will control the loose smut.

In one of the States, community seed-treating plants for applying the modified hot-water treatment have been established and found very satisfactory. Usually they are managed by the county agricultural agent or by a group of neighborhood farmers. Through the use of treated seed and of seed from crops produced from the treated seed a number of large, relatively smut-free areas have been established. The beneficial effects of the treatment are made more lasting in this way, as the fields within the smut-free areas are mutually protected from infection by loose smut.

### CONTROL UNDER IRRIGATION

Loose smut rarely is found in wheats grown on dry land in arid climates. Recent experiments have shown that low relative humidity of the atmosphere during the inoculation period, that is, when the sound wheat heads are in bloom, inhibits the germination of loose-smut spores, thus reducing or preventing infection. Therefore, in arid climates it should be possible to control loose smut in wheats grown under irrigation by withholding water during the blooming period. Thus, the influence of the normally dry atmosphere in preventing infection would be given full play. Details for the practical application of this method of control have not yet been worked out.

### RESISTANT VARIETIES

The important wheat varieties of the eastern United States and a few of the most important varieties of the western United States have been tested 2 or more years for resistance to loose smut. Thousands of individual wheat flowers have been inoculated by hand in order to insure infection. As a result, highly resistant or nearly immune strains have been found in the following wheats: Preston (hard red spring common); Bacska, Blackhull, Hussar, Ridit (hard red winter common); Forward, Fulcaster, Leap, Purplestraw, Russian, Sol, Trumbull, and Wyandotte (soft red winter common). These strains have not yet been tested for yield and quality, but if found satisfactory they will become valuable factors in reducing the losses caused by loose smut.

## FLAG SMUT

Flag smut has long been prevalent in Australia, where it is one of the most destructive diseases of the wheat crop. Under some conditions this disease often destroys 10 percent of the crop, and losses of one half of the crop are not rare. Flag smut also occurs in China, Japan, India, South Africa, Italy, and Spain.

In the United States, flag smut was discovered in Missouri in 1918. Later it was found in several counties of Illinois near St. Louis, Mo., and in several counties in Missouri and Kansas near Kansas City. Recent surveys indicate that the range of the disease is gradually increasing from these centers of infection.

### DESCRIPTION

Flag smut appears as long black stripes running lengthwise on the leaf blades and on the upper parts of the stems of the plants, as shown in figure 10.

Infection in the field usually can be detected by short or more or less dwarfed stalks which seldom produce heads. Usually the entire plant is affected, although partly infected plants are not uncommon in certain varieties. When infected leaves dry, they split along the black streaks and free the black powdery spores of the smut fungus (*Urocystis tritici*). The spores fall to the ground, are blown to adjoining plants, and are spread by the feet of animals and man and by machinery. When infected wheat is being harvested, flag-smut spores are carried to the wheat kernels of uninfected plants. This smut lives over in the soil, or, as is the case with bunt, it may be carried on contaminated wheat seed. Infection of the young wheat seedlings takes place during germination. After entering the seedling the fungus remains inside the plant, but infected plants can be detected by the black streaks on the leaves before the jointing of the plant begins.

### CONTROL METHODS

Flag smut of wheat can be controlled by quarantine and sanitation, seed treatment, and the growing of resistant varieties.

### QUARANTINE AND SANITATION

Since flag smut is not generally distributed throughout the United States, any material, such as straw, manure, etc., that contains flag-

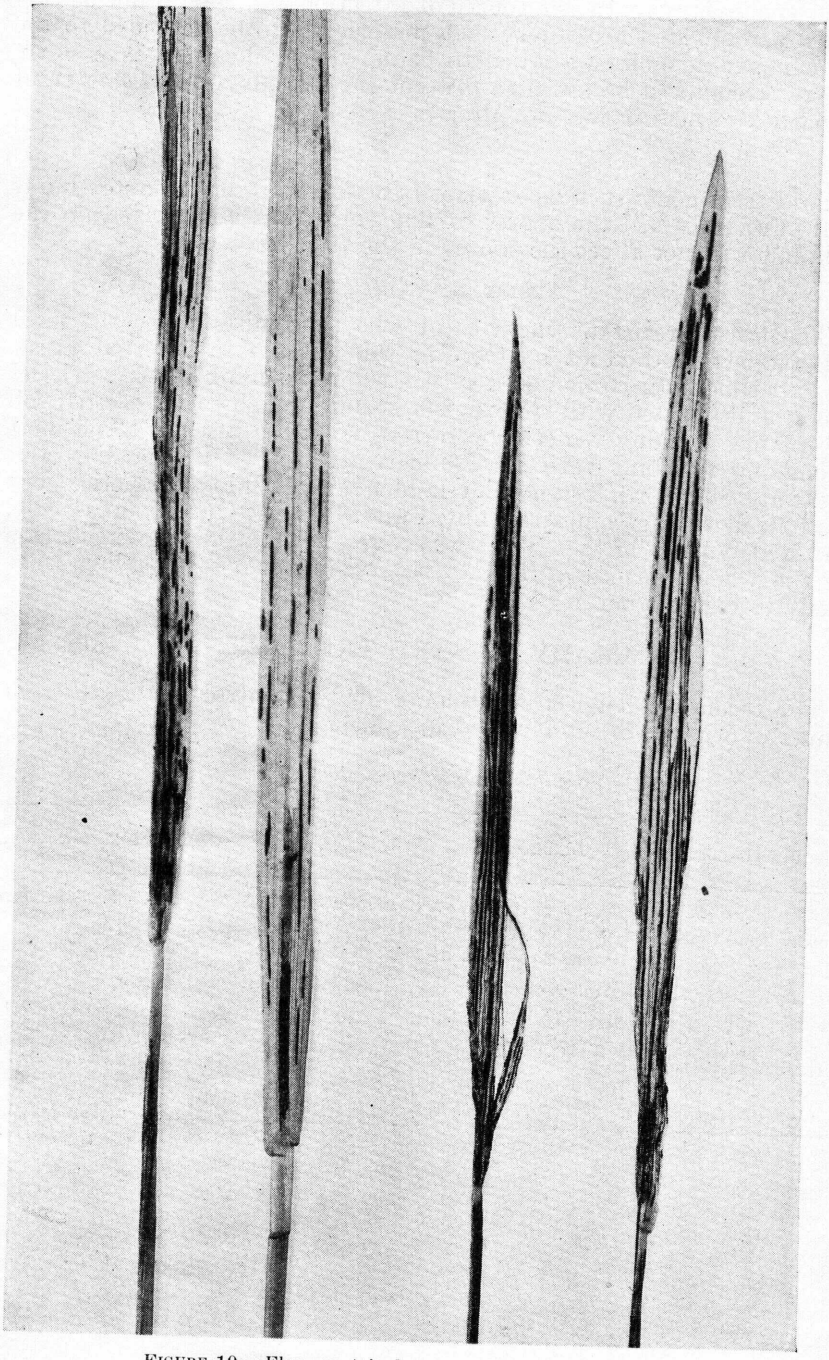

FIGURE 10.—Flag smut in leaves and stalks of wheat.

smut spores may serve as a source of infection and should not be carried to uninfested areas. If such material is to be returned to the land, it should not be applied to fields where wheat is to be sown. Great care should be taken to prevent the introduction of flag smut into States where it does not already exist.

### SEED TREATMENT

Seed treatments such as described for the stinking smuts or bunts will effectively kill the spores of flag smut that are carried on the seed but will not affect the spores in the soil.

### RESISTANT VARIETIES

The use of resistant varieties of wheat promises to be the most satisfactory method of controlling this disease in infested areas. In experiments in which seed of a large number of wheat varieties was heavily dusted with spores of flag smut and sown in infested soil the plants of many varieties were free from the disease. The most promising resistant varieties commercially grown in the flag-smut areas are Shepherd, Trumbull, Gladden, and Fulhio. Varieties very susceptible to flag smut are Flint, Fultz, Harvest Queen, Jones Fife, and Red Wave. If these varieties are replaced in the flag-smut areas by the wheat varieties found to be resistant, no serious losses are likely to result from flag smut.

## SUMMARY OF SEED TREATMENTS

The recommended seed treatments for the control of the different smuts of wheat are summarized in table 1.

TABLE 1.—*Seed treatments for control of wheat smuts*

| Kind of smut | Disinfectant | Quantity, strength, or temperature | Duration of treatment |
|---|---|---|---|
| Stinking smuts (bunts) | Copper carbonate (*Caution:* Do not inhale dust). | 2 to 3 ounces per bushel. | Mix in tightly closed container until each kernel is coated with dust. |
| | Formaldehyde | 1 pint to 40 gallons of water. | Soak 10 minutes, skim off smut balls. |
| Flag smut | Treat as for stinking smut. | | |
| Loose smut | Hot water (presoak or modified method). | 129° F. | Soak 4 to 6 hours in cold water, dip in water at about 120° F. for a moment, then soak 10 minutes at 129°. |
| | Hot water (single-bath method). | 120° F. | Soak 1 hour and 35 minutes. |

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